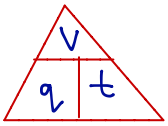
flow rate = q

Fluids, Work, and Power

SPH4C



Fluids may be used to do Work.

The movement of fluid is a system is often given in terms of the flow rate:

↳ volume / time

Example: A water jet cutter needs a flow rate of 3.3 L/min and a time of 18 s to cut a certain metal component. What is the volume of water required?

Given: $q = 3.3\ L/min$

$t = 18\ s \times \frac{1\ min}{60\ s} = 0.3\ min$

Unknown: Volume = V

Steps: $V = q \cdot t$

$V = 3.3\ \frac{L}{min} \times 0.3\ min$

$V = 0.99\ L$

To convert litres to cubic metres, use the conversion factor:

$1\ cm^3 = 1\ mL$

$0.01m \times 0.01m \times 0.01m = 0.001\ L$

$0.000001\ m^3 = 0.001\ L$

Example:

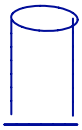
$\therefore \frac{0.001L}{0.000001} = 1\ m^3$

$1000\ L = 1\ m^3$

The speed of the fluid may be determined by:

Flowrate ÷ Area

If the volume is a cylinder, the area is: $A = \pi r^2$



Example: If the radius of the water jet cutter is 0.34 mm, what is the speed of the water?

$q = 3.3\ L/min$

Convert: L/min into m^3/s

$3.3\ \frac{L}{min} \times \frac{1\ m^3}{1000\ L} \times \frac{1\ min}{60\ s}$

$3.3\ L/min = 5.5 \times 10^{-5}\ \frac{m^3}{s}$

$q = 5.5 \times 10^{-5}\ \frac{m^3}{s}$

$0.34\ mm \div 1000 = 0.00034\ m$

$A = \pi r^2$

$= 3.14(0.00034\ m)^2$

$= 3.14(1.156 \times 10^{-7}\ m^2)$

$A = 3.63 \times 10^{-7}\ m^2$

$s = \frac{q}{A} = \frac{5.5 \times 10^{-5}\ \frac{m^3}{s}}{3.63 \times 10^{-7}\ m^2}$

$= \frac{5.5}{3.63} \times 10^{2}\ \frac{m}{s}$

$= 1.5 \times 10^{2}\ m/s$

$s = 150\ m/s$

The equations for pressure, work, and power are, as before:

$p = F/A$

$W = Fd$

$P = W/\Delta t$

Example: If the water jet cutter exerts a force of 120 N, what is (a) the pressure and (b) the power of the water jet?

a) $P = \frac{F}{A}$

$= \frac{120\ N}{3.63 \times 10^{-7}\ m^2}$

$P = 357\,142\,857\ Pa$

$P = 357\,142\ kPa$

More Practice: Liquid in a cylinder exerts a pressure of 10 000 kPa on a piston of radius 8.0 cm. The piston moves 34 cm in 6.8 s. Calculate the:

(a) force on the piston

$F = p \times A$

(b) work done on the piston

$W = Fd$

(c) power of the system

$P = \frac{W}{t}$